

WHAT IS CLAIMED IS:

- 1 1. A cracking tube comprising:
2 a first layer on an interior surface of the tube; and
3 a second material surrounding the lining,
4 wherein the first layer is an iron aluminide alloy having a coefficient of
5 thermal expansion substantially the same as the coefficient of thermal expansion of
6 the second material over the temperature range of ambient to about 1000 °C.
- 1 2. The cracking tube of claim 1, wherein the iron aluminide alloy is
2 a sintered iron aluminide alloy or a composite of iron aluminide alloy.
- 1 3. The cracking tube of claim 1, wherein the second material is
2 INCO 803 or HP steels.
- 1 4. The cracking tube of claim 1, wherein the iron aluminide alloy
2 includes at least 2 vol. % transition metal oxides selected from alumina, yttria,
3 ceria, zirconia, or lanthanum.
- 1 5. The cracking tube of claim 4, wherein the iron aluminide includes
2 at least 14 wt. % aluminum.
- 1 6. The cracking tube of claim 4, wherein the iron aluminide alloy
2 includes an additive present in an amount which improves metallurgical bonding
3 between the oxide filler and the iron aluminide alloy, the additive comprising at
4 least one refractory carbide.

1 7. The cracking tube of claim 1, wherein the iron aluminide alloy
2 comprises:

3 14-32 wt. % Al;
4 10-14 vol. % transition metal oxides;
5 0.003 to 0.020 wt. % B;
6 0.2 to 2.0 wt. % Mo;
7 0.05 to 1.0 wt. % Zr;
8 0.2 to 2.0 wt. % Ti;
9 0.10 to 1.0 wt. % La;
10 0.05 to 0.2 wt. % C;
11 balance Fe; and
12 optionally, ≤ 1 wt. % Cr.

1 8. The cracking tube of claim 1, wherein the first layer comprises
2 an extruded layer on the inside of the tube.

1 9. The cracking tube of claim 1, wherein the alloy is in the form of
2 a nanocrystalline intermetallic powder.

3 10. A method of reforming a hydrocarbon feed in the cracking tube
4 of claim 1, comprising passing of a mixture of steam and the hydrocarbon feed
5 through the cracking tube while heating the tube to at least 800° C.

1 11. A method of manufacturing the cracking tube of claim 1,
2 comprising the steps of:
3 forming the first layer from a powder of 14-32 wt. % Al, 10-14 vol. %
4 transition metal oxides, 0.003 to 0.020 wt. % B, 0.2 to 2.0 wt. % Mo, 0.05 to 1.0
5 wt. % Zr, 0.2 to 2.0 wt. % Ti, 0.10 to 1.0 wt. % La, 0.05 to 0.2 wt. % C, balance

6 including Fe, and optionally ≤ 1 wt. % Cr, the powder having been prepared by
7 mechanical alloying, gas atomization, or water atomization techniques.

1 12. The method of claim 11, wherein transition metal oxides are
2 oxides of aluminum, yttria, ceria, zirconia, or lanthanum

1 13. The method of claim 12, wherein transition metal oxides are
2 Al_2O_3 , Y_2O_3 , CeO , Zr_2O_3 , or LaO .

1 14. The method of claim 11, wherein the first layer is formed by co-
2 extrusion with the second material of the cracking tube, the co-extrusion carried
3 out at a minimum of 800 °C by using a cold isostatically pressed (CIP) billet or a
4 hot isostatically pressed (HIP) billet.

1 15. The method of claim 14, wherein the billet formed by cold
2 isostatic pressing is obtained by reaction synthesis or mechanical alloying of iron
3 aluminide with mixed oxides.

1 16. The method of claim 11, wherein the second material of the
2 cracking tube is an INCO 803 steel, a HP steel, or one of the Fe-, Cr-, or Ni-
3 based alloys with a minimum of 10 wt. % of Cr or Ni.

1 17. The method of claim 11, wherein the first layer is formed by
2 thermal spraying techniques.

1 18. The method of claim 17, wherein thermal spraying techniques are
2 plasma spraying or high velocity oxy-fuel spraying.

1 19. The method of claim 11, wherein the first layer comprises a
2 cladding.

1 20. The cracking tube of claim 1, further comprising:
2 an intermediate layer disposed between the first layer and the
3 second material,
4 wherein the intermediate layer has a coefficient of thermal expansion
5 between the coefficients of thermal expansion of the first layer and the second
6 material

1 21. A method of reducing coking and carburization in a cracking tube
2 having a metallurgically modified surface on the inner diameter surface thereof
3 and the cracking tube is used in an environment in which hydrocarbon feedstock is
4 thermally and/or catalytically converted to hydrocarbon products, comprising:
5 heating the cracking tube to a first temperature at which cracking
6 of hydrocarbon feedstock occurs;
7 flowing hydrocarbon through the cracking tube; and
8 producing an effluent containing a desired hydrocarbon product,
9 wherein the metallurgically modified surface is an iron aluminide alloy
10 having a coefficient of thermal expansion substantially the same as the coefficient
11 of thermal expansion of a second material of the cracking tube over the
12 temperature range of ambient to about 1000 °C, and wherein the modified surface
13 is substantially coke and carburization-free after a period of time in which a
14 similar cracking tube without the metallurgically modified surface of iron
15 aluminide alloy exhibits coking and carburization.

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1 22. The method of claim 21, wherein the iron aluminide alloy
2 comprises:
3 14-32 wt. % Al;
4 10-14 vol. % transition metal oxides;
5 0.003 to 0.020 wt. % B;
6 0.2 to 2.0 wt. % Mo;
7 0.05 to 1.0 wt. % Zr;
8 0.2 to 2.0 wt. % Ti;
9 0.10 to 1.0 wt. % La;
10 0.05 to 0.2 wt. % C;
11 balance Fe; and
12 optionally, ≤ 1 wt. % Cr.

1 23. In a process of producing hydrocarbon products from feedstock
2 utilizing a cracking tube, the improvement comprising passing the feedstock
3 through a cracking tube having a metallurgically modified surface of iron
4 aluminide alloy disposed on the inner surface of the cracking tube such that
5 feedstock is in fluid communication with the metallurgically modified surface.

1 24. In the process of claim 23, wherein the metallurgically modified
2 surface is an iron aluminide alloy having a coefficient of thermal expansion
3 substantially the same as the coefficient of thermal expansion of a second material
4 of the cracking tube over the temperature range of ambient to about 1000 °C.

1 25. In the process of claim 23, wherein the iron aluminide alloy
2 comprises:
3 14-32 wt. % Al;
4 10-14 vol. % transition metal oxides;
5 0.003 to 0.020 wt. % B;
6 0.2 to 2.0 wt. % Mo;
7 0.05 to 1.0 wt. % Zr;
8 0.2 to 2.0 wt. % Ti;
9 0.10 to 1.0 wt. % La;
10 0.05 to 0.2 wt. % C;
11 balance Fe; and
12 optionally, ≤ 1 wt. % Cr.

1 26. In the process of claim 23, wherein the period of time between
2 successive decoking operations is extended by at least 10 percent as compared to
3 the time between successive decoking operations in a substantially similar cracking
4 tube that does not have a metallurgically modified surface of iron aluminide alloy
5 disposed on the inner surface and in fluid communication with the feedstock.

1 27. In a cracking tube, the improvement comprising:
2 a metallurgically modified surface of iron aluminide alloy
3 disposed on the inner surface of the cracking tube,
4 wherein the feedstock is in fluid communication with the metallurgically
5 modified surface and wherein the coefficient of thermal expansion of the iron
6 aluminide alloy is substantially the same as the coefficient of thermal expansion of
7 a second material of the cracking tube over the temperature range of ambient to
8 about 1000 °C, the second material an outer material for the cracking tube.

- 1 28. In the cracking tube of claim 27, the improvement further
2 comprising:
3 an intermediate layer disposed between the iron aluminide alloy
4 and the second material, the intermediate layer having a coefficient of thermal
5 expansion between that of the iron aluminide alloy and the second material.
- 1 29. In the cracking tube of claim 27, wherein the iron aluminide alloy
2 comprises:
3 14-32 wt. % Al;
4 10-14 vol. % transition metal oxides;
5 0.003 to 0.020 wt. % B;
6 0.2 to 2.0 wt. % Mo;
7 0.05 to 1.0 wt. % Zr;
8 0.2 to 2.0 wt. % Ti;
9 0.10 to 1.0 wt. % La;
10 0.05 to 0.2 wt. % C;
11 balance Fe; and
12 optionally, ≤ 1 wt. % Cr.